Dynamic list scheduling of threads on clusters

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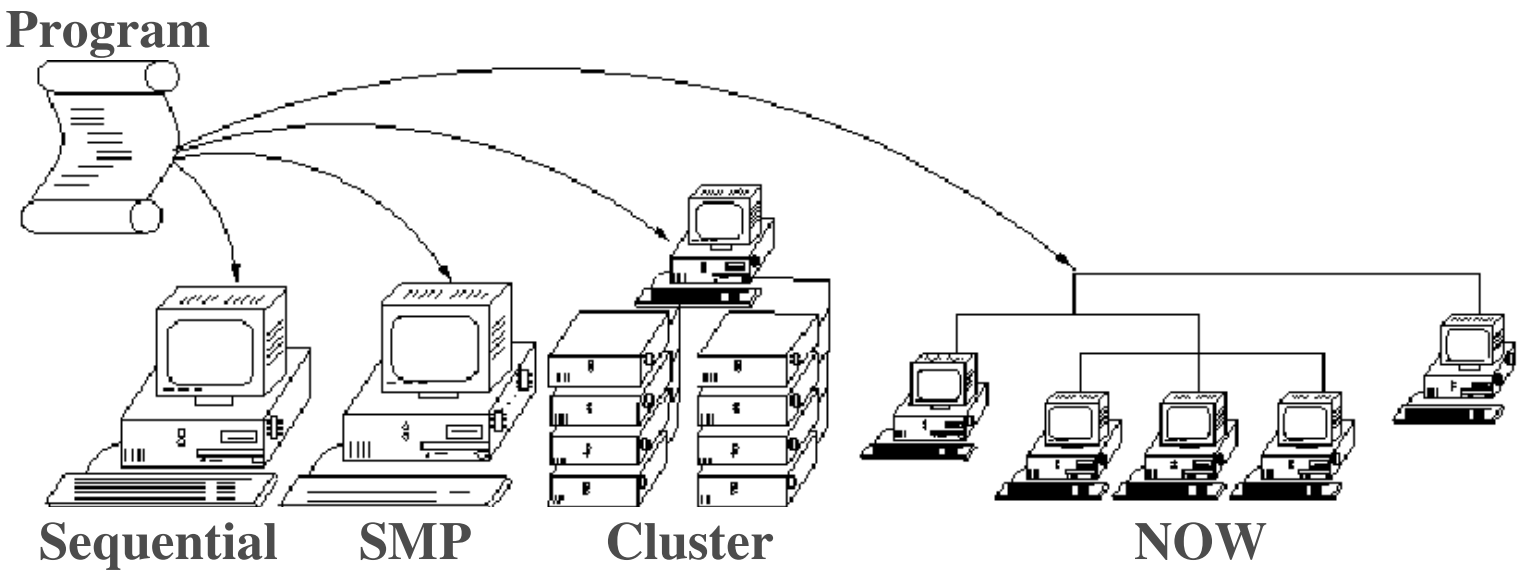
Overview

- **Introduction**
- **Anahy**
  - Task and synchronizations
  - Programming interface
  - Scheduling strategy
- **Handling a Graph of Tasks**
  - Visualizing an execution
- **Some Performances**
- **The Future of Anahy**

Introduction

- **Performance portability**



  - The concurrency of an application can be described regardless of hardware resources

Introduction

- **Performance portability**
- **Concurrency**
  - Depends on application characteristics
  - Can be identified by a specialist on the application
- **Parallelism**
  - Depends on hardware
  - A specialist on applications is not necessarily an specialist in parallel programming

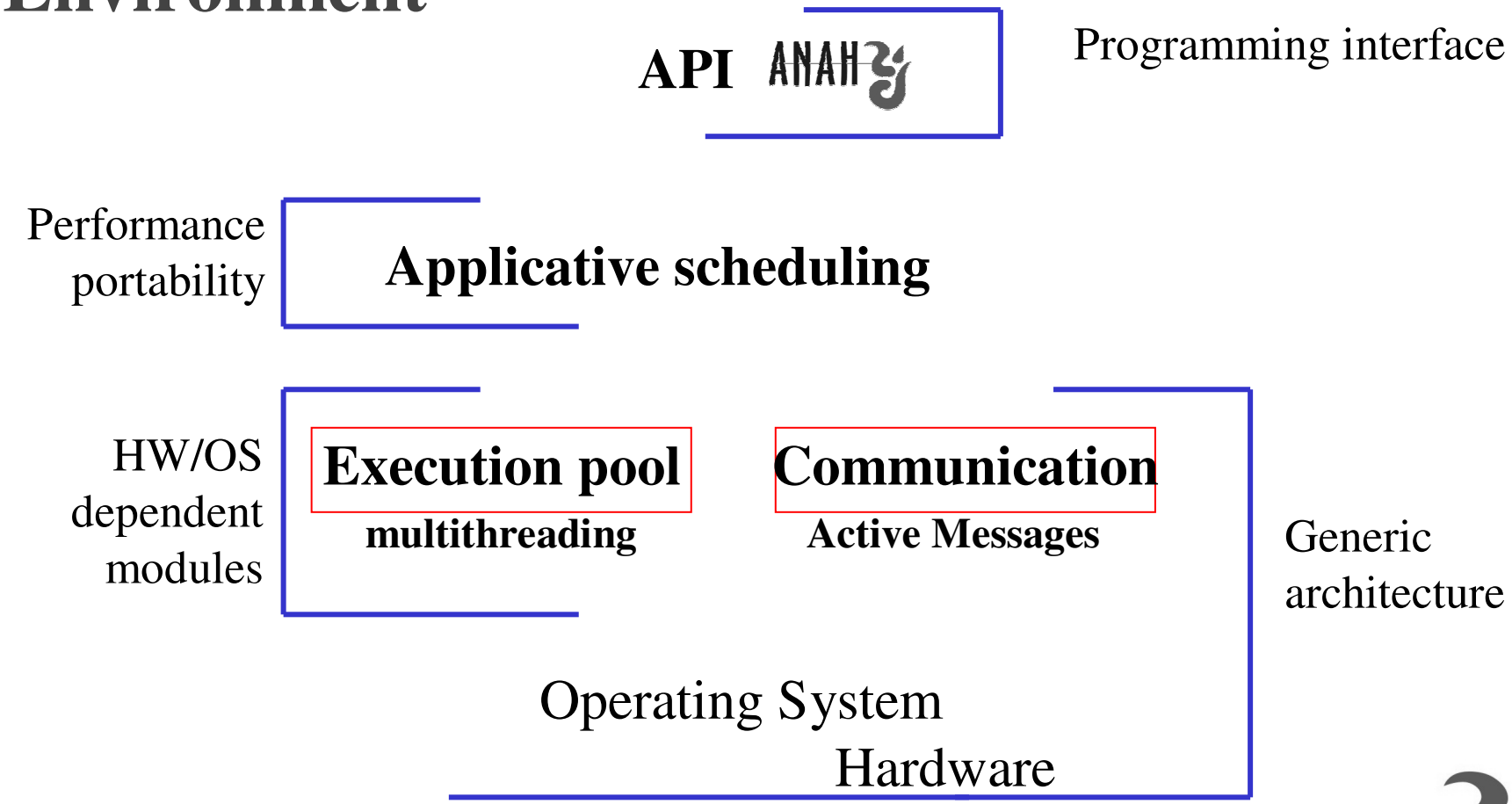
Concurrency >> Parallelism

Introduction

- **Performance portability**
- **Our approach:**
  - Dissociate programming of execution
- **Our proposal:**
  - ANAHY
- **Our mechanisms:**
  - Scheduling and dataflow control achieved at run time

Anahy

- **Environment**

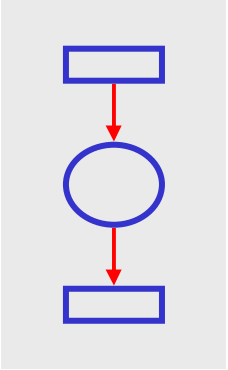


UNISINOS

Anahy

Task and Synchronization

- A ***task*** defines a sequence of instructions and two set of data: input and output data;
- The synchronization between tasks are guaranteed by accesses to the data



Anahy

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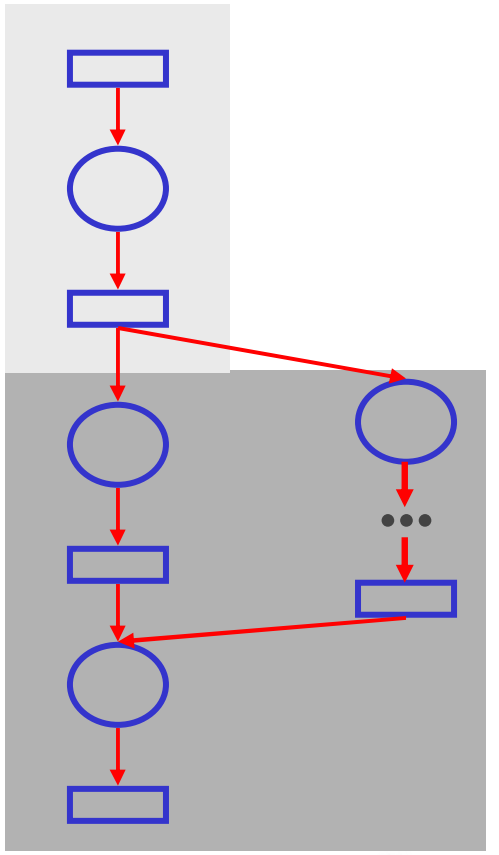

Large amount of concurrency

↳ **large amount of synchronizations**

Anahy

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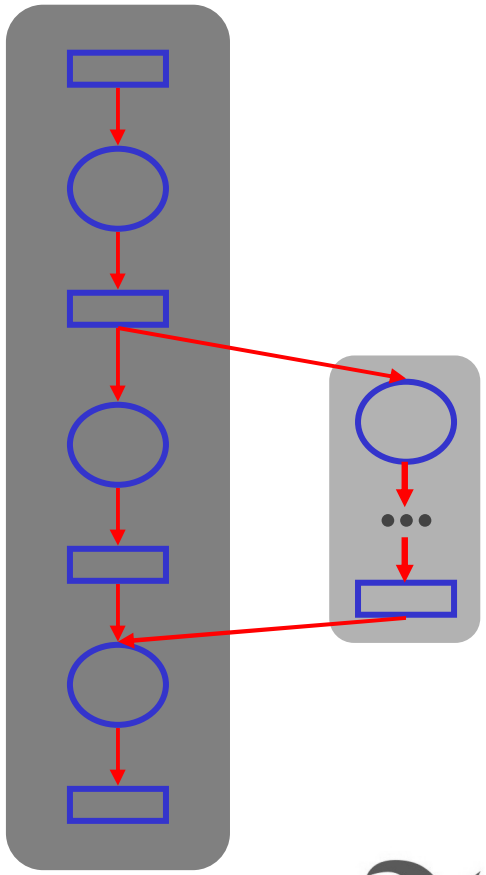


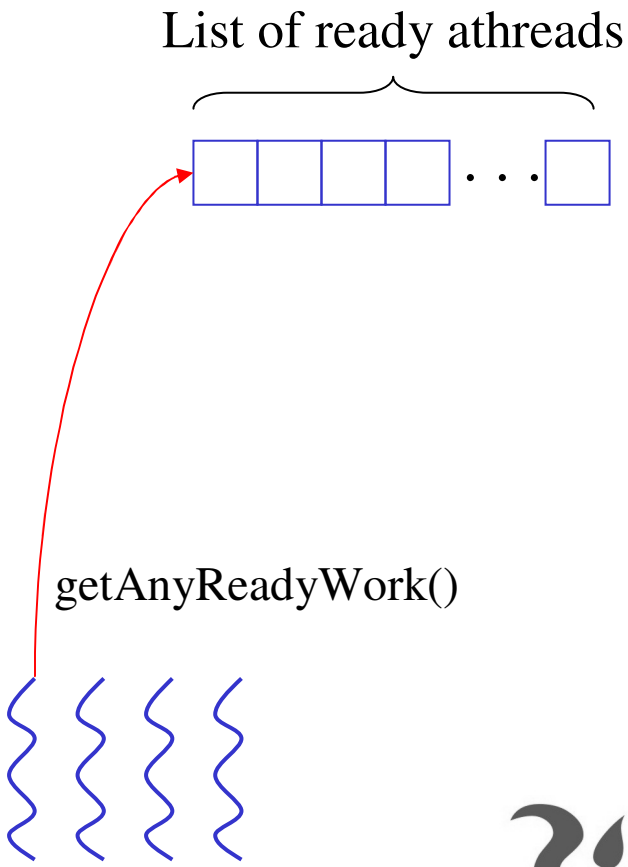
Large amount of concurrency

↳ **large amount of synchronizations**

Coarse scheduling unity: athread

Anahy

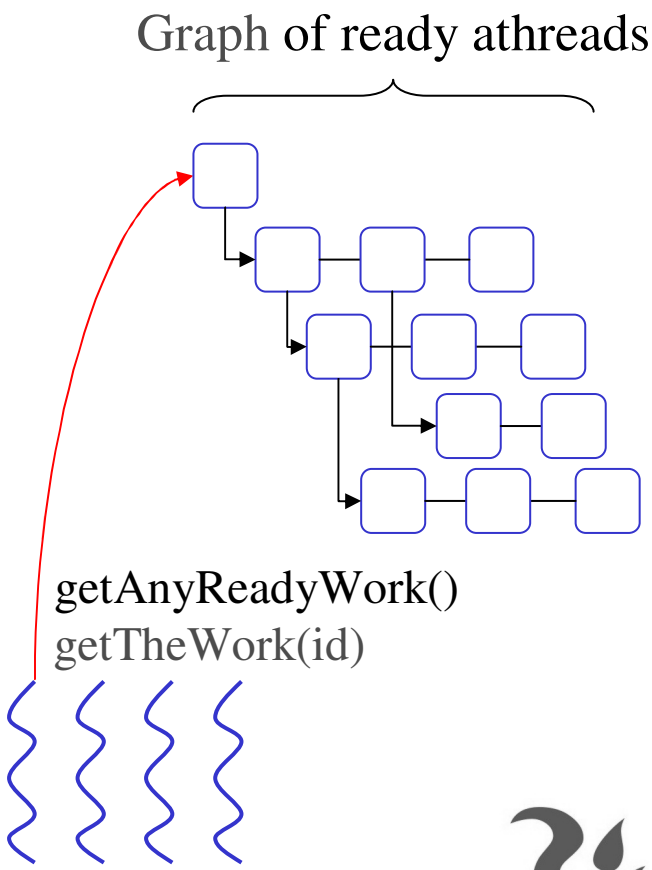
- Execution pool
  - A set of *system* threads is responsible for executing the athreads
  - Each system thread is called VP
  - Strategy:
    - A VP can chose a specific athread to execute



UNISINOS

Anahy

- Execution pool
  - A set of *system* threads is responsible for executing the athreads
  - Each system thread is called VP
  - Strategy:
    - A VP can chose a specific athread to execute
    - The list of ready works is organized as a graph of dependencies



UNISINOS

Anahy

- Programming Interface
- Creation

```
int athread_create( athread_t *th,
                    athread_attr_t *attrib,
                    void *(*func) (void *),
                    void *in );
```

- Synchronization

```
int athread_join( athread_t th, void **res );
```

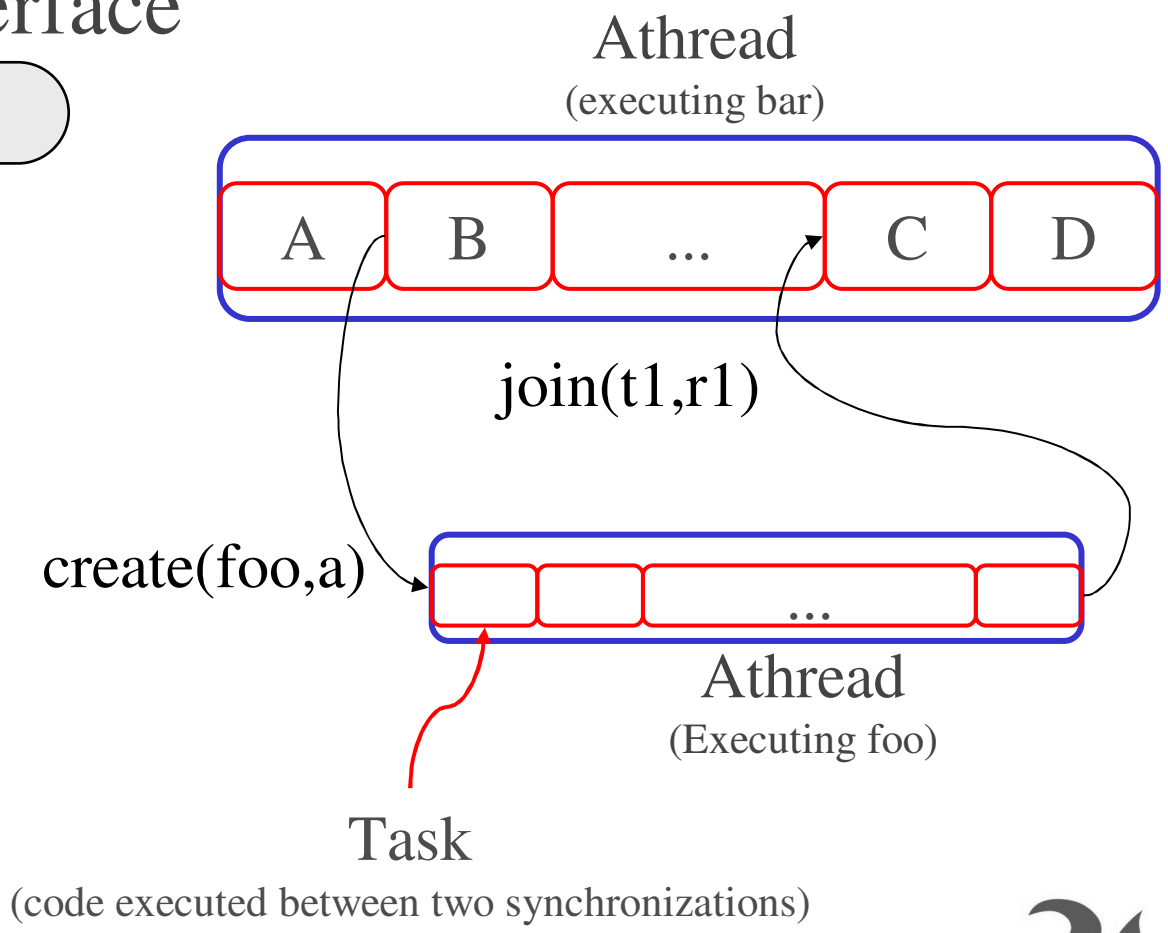
- Athread code

```
void *foo( void *in ) {
  ...
  return out;
}
```


Anahy

- Programming Interface

```
void* foo(void* x) {
 ...
}
void* bar(void* p) {
 Task_A
 t1 = create(foo,a);
 Task_B
 t2 = create(fuu,b);
 ...
 join(t1,r1)
 Task_C
 join(t2,r2)
 Task_D
 return &something;
}
```



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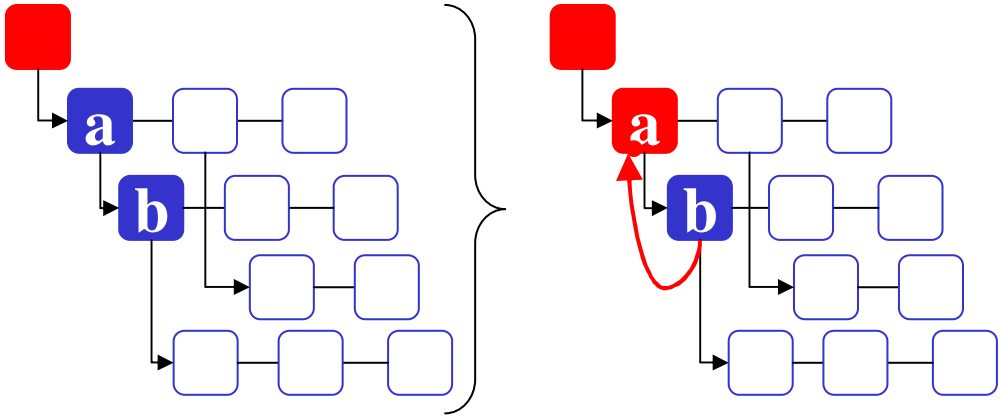
Anahy

- Scheduling
- List scheduling
  - Blind strategy
    - Explosion on concurrency or memory
- Scheduling heuristics
  - Different searches on the graph
- Applied:
  - When a VP becomes idle and request for work
  - When is executed a join operation

Handling graph of tasks

- Search an athread on the graph:
  - athread_t* SearchFrom(from, direction, orientation, axis)



a.Join(b)

Handling graph of tasks

- Search an athread on the graph:
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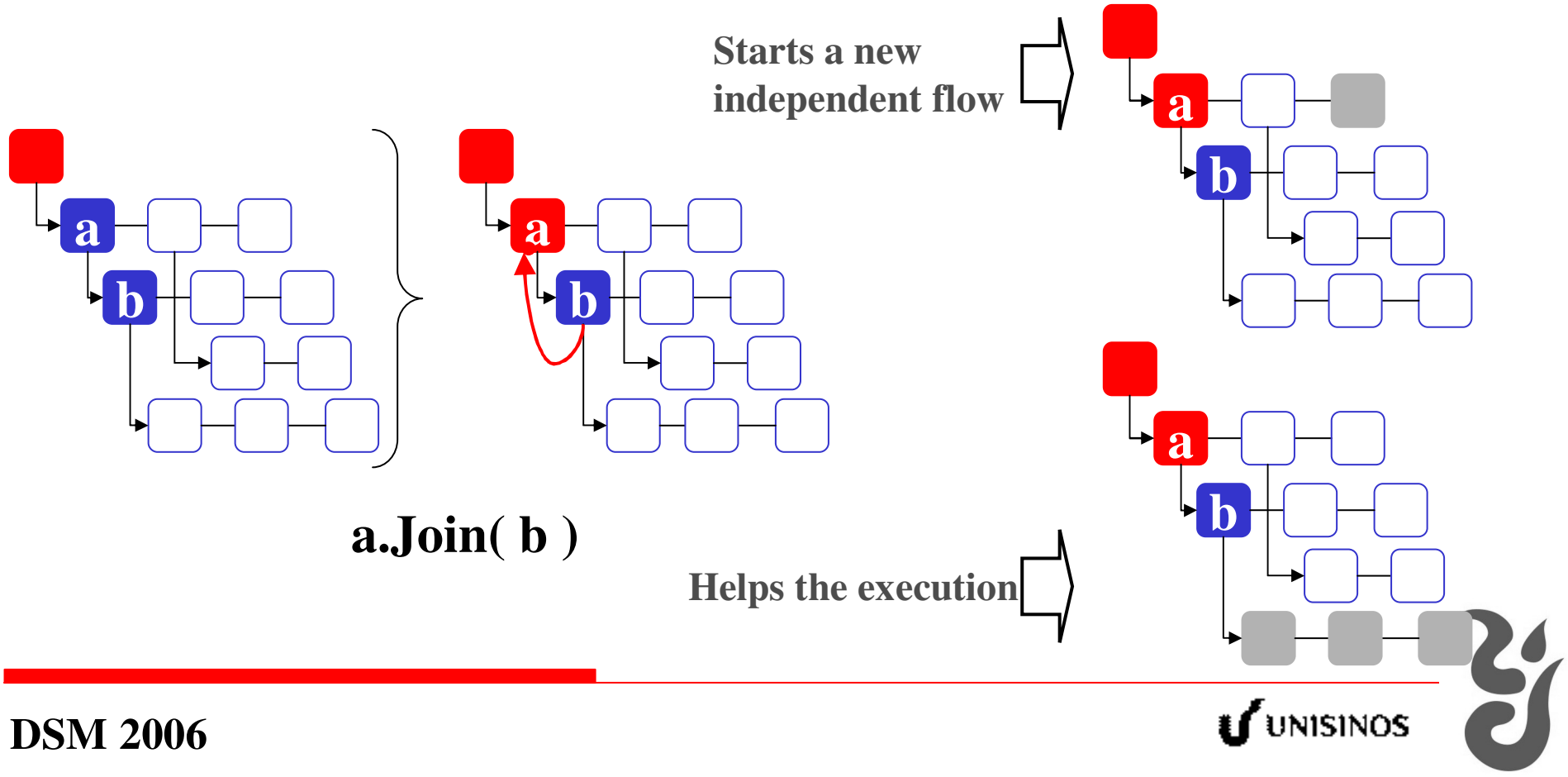

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Handling graph of tasks

- Examples
  - SearchFrom(current, ROOT, LEFT, VERT)
    - returns the next athread ready in the sub-graph having current as root (left-to-right, high priority on deep nodes)
  - SearchFrom(NULL, TOP, RIGHT, HORIZ)
    - returns the next athread ready in the graph from the first node of the graph (right-to-left, high priority on high nodes).
  - SearchFrom(jid, ROOT, RIGHT, HORIZ)
    - returns the next athread ready in the sub-graph having jid as root (right-to-left, high priority on the higest athread in the sub-graph).

Handling graph of tasks

- Visual example
  - Recursive program:

```
void* tree( void* n ) {
 if( n > 2 ) {
   t1 = create( tree, *n-1 );
   t2 = create( tree, *n-2 );
   doSomething( ... );
   join(t1,&r1);
   join(t2,&r2);
 }
 else doSomething( ... );
 return &something;
}
```

  - VP idle:
    - searches the last created in the highest level

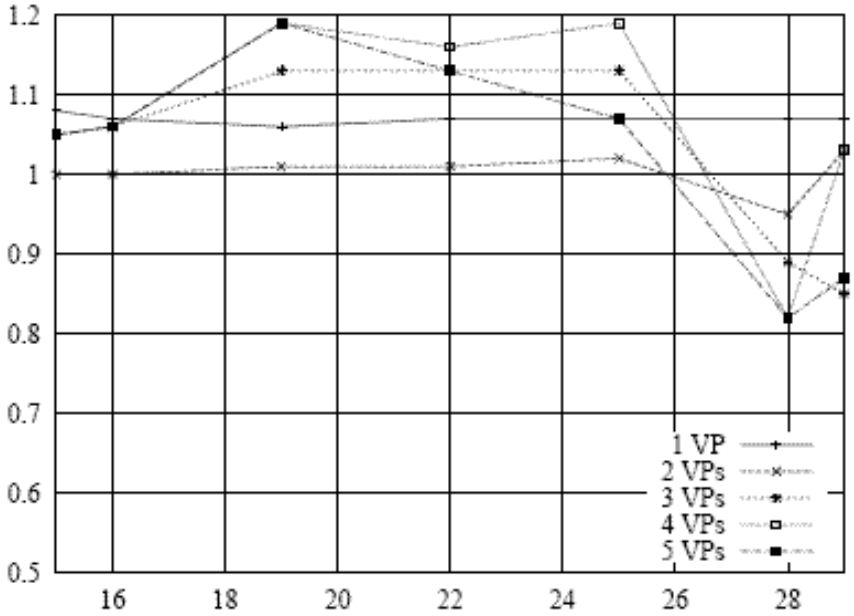
      SearchFrom(NULL, TOP, RIGHT, HORIZ)
  - athread blocked in a join:
    - searches a ready athread from jid

      SearchFrom(jid, HERE, RIGHT, HORIZ)

Performance

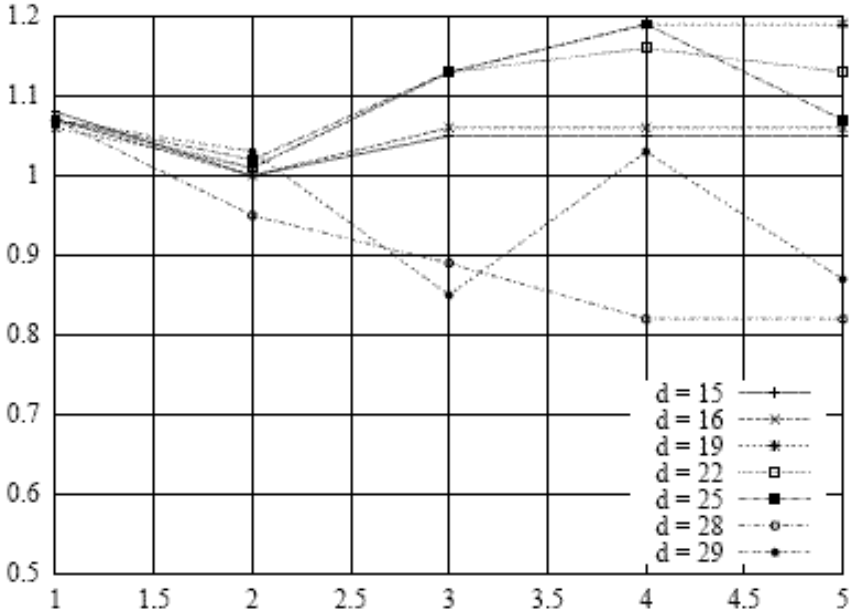
High Parallel Application

Ratio: Cilk / Anahy on a dual-processor



Depth

Concurrency level on the program



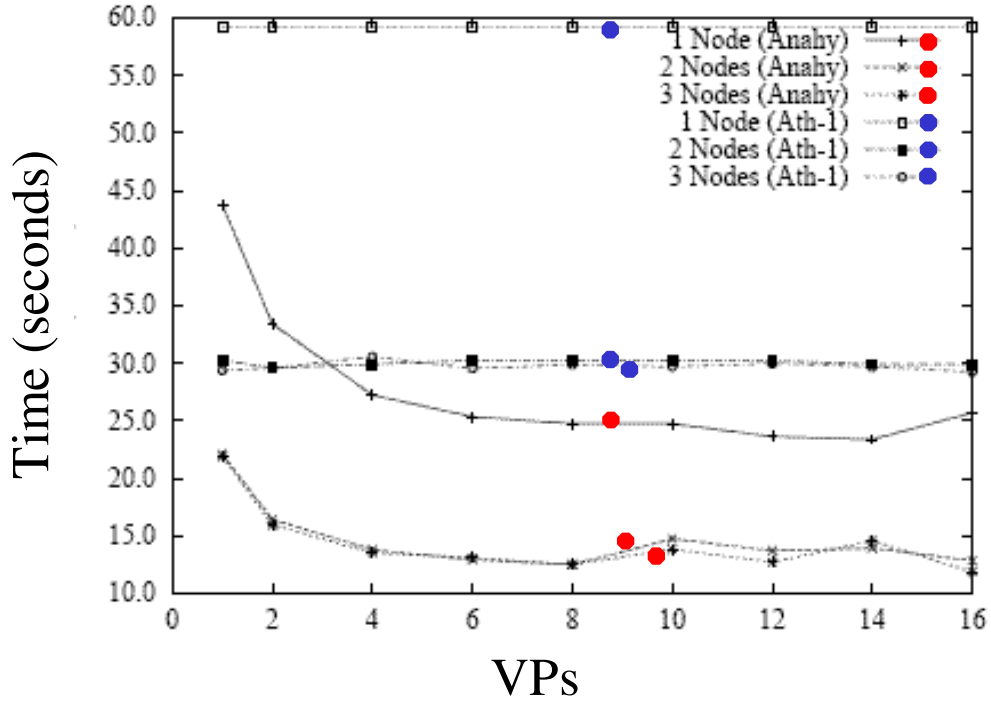
VPs

Parallel execution support

Performance

High Parallel Application

Execution times: Athapascan-1 *x* Anahy on a cluster



Parallel execution support per node

The future of Anahy

- Current work
  - Distributed version
  - Real applications
    - Dynamic programming
    - Metabolic cellular network
    - Crowd simulation
- Next
  - Scheduling strategies
- Next++
  - Other Pthreads synchronization mechanisms
    - Mutex, condition variables

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